

What is claimed is:

1. An atomic force microscope (AFM) capable of observing the topography of a sample surface at high speed with a high resolution under the atmospheric pressure, comprising:
    - a plurality of scanning probes for measuring the sample surface, wherein each of the scanning probes includes a cantilever having a tip and a first and a second actuator;
    - means for detecting a light beam reflected from said each of the scanning probes to convert same into a first signal in response to a second signal; and
    - means for driving the scanning probes by generating a third and a fourth signal and detecting information regarding the topography of the sample surface,
  - 15       wherein the first actuator performs a tapping operation in response to the third signal, the second actuator performs a positioning operation in response to the fourth signal and the frequency of the third signal is higher than that of the fourth signal.
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2. The AFM according to claim 1, further comprising:
    - means for emitting the light beam;
    - means for scanning the light beam to said each of the scanning probes under the control of the driving means; and
    - 25       means for displaying thereon an image representing the topography of the sample surface.

3. The AFM according to claim 2, wherein the driving means includes:

means for filtering the first signal to extract a frequency component different from the frequency component

5 of the third signal, wherein the extracted frequency component is directly related to the information regarding the topography of the sample surface;

means for generating the third signal to provide same to the first actuator;

10 means for generating the fourth signal to provide same to the second actuator;

means for generating the second signal based on the first signal, in order to control the light beam scanning means; and

15 means for calculating a displacement of the cantilever moved in a normal direction with respect to the sample surface to generate a sixth signal bearing the information based on the extracted frequency component.

20 4. The AFM according to claim 3, wherein the light beam scanning means scans the light beam to said each of the scanning probes depending on the second signal generated from the driving means.

25 5. The AFM according to claim 4, wherein the tip is provided on a free end of the cantilever.

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6. The AFM according to claim 5, wherein the driving means further includes:

means for generating a fifth signal based on the second signal; and

5 a switching block for selecting an output terminal connected to the second actuator of said each of the scanning probes, in response to the fifth signal, thereby providing the fourth signal to the second actuator.

10 7. The AFM according to claim 6, wherein the first and the second actuator are provided on the cantilever opposite to the free end thereof where the tip is provided.

15 8. The AFM according to claim 7, wherein the first actuator is arranged on the cantilever opposite to the second actuator.

9. The AFM according to claim 8, wherein the detecting means includes:

20 a plurality of photo-detectors for detecting and converting the light beam into the first signal; and  
a multiplicity of signal amplifiers for amplifying the level of the first signal into a predetermined signal level,  
wherein each of the photo-detectors is connected to  
25 at least one of the signal amplifiers.

10. The AFM according to claim 9, wherein the detecting means further includes a switching block for selecting one of the signal amplifiers in response to the fifth signal.

5 11. The AFM according to claim 10, wherein the calculation  
means computes a displacement corresponding to a deflection  
amount of the cantilever based on the extracted frequency  
component and the frequency component of the third signal to  
thereby generate the sixth signal, wherein the deflection of  
10 the cantilever is caused by the inter-atomic force between  
the tip and the sample surface to be observed.

12. The AFM according to claim 11, wherein the fourth  
signal drives the second actuator to perform a positioning  
15 operation, wherein the positioning operation restores a  
deflection state of the cantilever to an equilibrium state  
thereof at a measurement point on the sample surface without  
changing the current position of the cantilever.

20 13. The AFM according to claim 12, wherein the tapping operation is an operation in which the tip periodically comes in contact with and then off the sample surface with a constant time interval.

25 14. The AFM according to claim 13, wherein the image  
representing the topography of the sample surface is

reconstructed based on the sixth signal.

15. The AFM according to claim 14, wherein the sixth  
signal corresponds to the deflection amount of the  
5 cantilever.

16. An atomic force microscope (AFM) capable of observing the topography of a sample surface at high speed with a high resolution under the atmospheric pressure, comprising:

10 a scanning probe matrix having  $N \times M$  scanning probes thereon for measuring the sample surface, wherein each of the scanning probes includes a cantilever having a tip and a first and a second actuator,  $N$  and  $M$  being positive integers greater than 1, respectively;

15 means for detecting a light beam reflected from said  
each of the scanning probes to convert same into an  
electrical signal; and

means for driving the scanning probes by generating a reference and a servo signal and detecting information regarding the topography of the sample surface,

wherein the first actuator performs a tapping operation in response to the reference signal, the second actuator performs a positioning operation in response to the servo signal and the frequency of the reference signal is higher than that of the servo signal.

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17. The AFM according to claim 16, further comprising:  
means for emitting the light beam;  
means for scanning the light beam to said each of the  
scanning probes under the control of the driving means; and  
5 means for displaying thereon an image representing the  
topography of the sample surface.

18. The AFM according to claim 17, wherein the driving  
means includes:

10 means for filtering the electrical signal to extract a  
frequency component different from the frequency component  
of the third signal, wherein the extracted frequency  
component is directly related to the information regarding  
the topography of the sample surface;  
15 means for generating the reference signal to provide  
same to the first actuator;  
means for generating the servo signal to provide same  
to the second actuator;  
means for generating a position signal based on the  
20 electrical signal, in order to control the light beam  
scanning means; and  
means for calculating a displacement of the cantilever  
moved in a normal direction with respect to the sample  
surface to generate a displacement signal bearing the  
25 information based on the extracted frequency component.

19. The AFM according to claim 18, wherein the light beam scanning means scans the light beam to said each of the scanning probes depending on the position signal.

5 20. The AFM according to claim 19, wherein the scanning probe matrix includes a same number of openings as the number of the scanning probes.

10 21. The AFM according to claim 20, wherein the width of each of the openings is determined by an incidence and a reflection angle of the light beam.

22. The AFM according to claim 21, wherein the tip is provided on a distal end of the cantilever.

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23. The AFM according to claim 22, wherein the driving means further includes:

means for generating the selection signal based on the position signal; and

20 a switching block for selecting an output terminal connected to the second actuator of said each of the scanning probes, in response to the selection signal, thereby providing the servo signal to the second actuator.

25 24. The AFM according to claim 23, wherein the first and the second actuator are provided on the cantilever opposite

to the distal end thereof where the tip is provided.

25. The AFM according to claim 24, wherein the first actuator is arranged on the cantilever opposite to the second actuator.

26. The AFM according to claim 25, wherein the detecting means includes:

a plurality of photo-detectors for detecting the light beam and converting same into the electrical signal; and  
10 a multiplicity of signal amplifiers for amplifying the level of the electrical signal to a predetermined signal level,

wherein each of the photo-detectors is connected to at least one of the signal amplifiers.

27. The AFM according to claim 26, wherein the detecting means further includes a switching block for selecting one of the signal amplifiers in response to the selection signal.

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28. The AFM according to claim 27, wherein the calculation means computes a displacement corresponding to a deflection amount of the cantilever based on the extracted frequency component and the frequency component of the reference signal to thereby generate the displacement signal, wherein  
25 the deflection of the cantilever is caused by the inter-

atomic force between the tip and the sample surface to be observed.

29. The AFM according to claim 28, wherein the servo  
5 signal drives the second actuator to perform a positioning  
operation, wherein the positioning operation restores a  
deflection state of the cantilever to an equilibrium state  
thereof at a measurement point on the sample surface without  
changing the current position of the cantilever.

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30. The AFM according to claim 29, wherein the tapping operation is an operation in which the tip periodically comes in contact with and then off the sample surface with a constant time interval.

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31. The AFM according to claim 30, wherein the image representing the topography of the sample surface is reconstructed based on the displacement signal.

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32. The AFM according to claim 31, wherein the displacement signal corresponds to the deflection amount of the cantilever.

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33. A method for driving an atomic force microscope (AFM) with plural scanning probes capable of observing the topography of a sample surface at high speed with a high

resolution under the atmospheric pressure, comprising the steps of:

- a) vibrating, responsive to a reference signal, a first actuator provided on each of the scanning probes;
  - 5 b) detecting a deflection amount of a cantilever provided with a tip at its free end; and
  - c) transmitting a servo signal to a second actuator based on the deflection amount of the cantilever,  
wherein the cantilever is provided on said each of the  
10 scanning probes and the first and second actuator are provided on the cantilever opposite to the free end where the tip is provided.

34. The method according to claim 33, wherein the step b)  
15 includes the steps of:

- b1) emitting a light beam toward a light beam scanner;
  - b2) generating a position signal for locating the light beam scanner to a predetermined position where the light beam is directed to one of the scanning probes;
  - 20 b3) detecting the light beam reflected from the tip portion of the cantilever; and
  - b4) converting the reflected light beam into an electrical signal to extract a frequency component thereof, wherein the extracted frequency component is different from the frequency component of the reference signal.

35. The method according to claim 34, wherein the extracted frequency component includes the information regarding the deflection of the cantilever.

5 36. The method according to claim 35, wherein the step c) includes the steps of:

c1) calculating a frequency component difference between the extracted frequency component and the frequency component of the reference signal; and

10 c2) generating the servo signal having a frequency corresponding to the calculated frequency component difference.

15 37. The method according to claim 36, wherein the calculated frequency component difference is directly related to the deflection amount of the cantilever.

20 38. The method according to claim 37, wherein the servo signal drives the second actuator to perform a positioning operation, wherein the positioning operation restores a deflection state of the cantilever to an equilibrium state thereof at a measurement point on the sample without changing the current position of the cantilever.

25 39. The method according to claim 38, wherein the first actuator is arranged on the cantilever opposite to the

second actuator.

40. The method according to claim 39, wherein the first actuator performs a tapping operation in response to the reference signal, wherein the tapping operation is an operation in which the tip periodically comes in contact with and then off the sample surface with a constant time interval.

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